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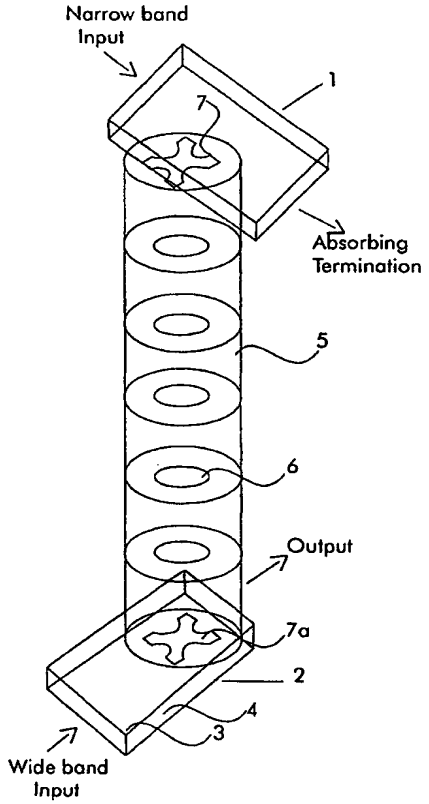
(54) Title: WAVEGUIDE DIRECTIONAL FILTER

(57) Abstract

A waveguide directional filter is described for combining multiple high power UHF television broadcasting transmitters on to a common antenna. The filter arrangement comprises an input waveguide (1) and an output waveguide (2). The waveguides are rectangular having broad walls (3) joined by narrow walls (4) whose width/height ratio is approximately 4:1. The two waveguides are connected by at least one direct–coupled cavity resonator (5). Coupling between the cavity and each waveguide is obtained by a respective characteristic aperture (7, 7a) in the form of a rectangle whose four sides have inwardly extending hemicycle sectors (8, 9, 10 and 11).



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WAVEGUIDE DIRECTIONAL FILTER

Field of Invention

This invention relates to the technology of combining multiple UHF TV broadcasting transmitters on to a common antenna.

Background of Invention

In this technology it is known to provide a UHF filter/combiner system comprising an assembly of dual bandpass filters whose inputs and outputs are coupled by waveguide hybrid couplers. A disadvantage of this known system is its relatively large size. Another disadvantage of this system is that the dual bandpass filters must be electrically identical, which is difficult to accomplish due to their complexity.

It is also known to provide a UHF filter/combiner that comprises a cascade of dual mode resonant cavities with input and output coaxial coupling elements, such as the "ROTAMODE" device. However, a disadvantage of this form of construction is that the power handling capability of the coaxial input and output elements is limited.

It is also known to use a waveguide directional filter technique at microwave multi-point distribution system(MMDS) frequencies above 2GHz. Each TV channel at MMDS frequencies occupies a fractional bandwidth of much less than 1%. However, at UHF broadcasting frequencies in the range 470-860 MHz, the fractional bandwidth of a TV channel is of the order of 1% or more, and a conventional waveguide directional filter does not provide a satisfactory electrical performance.

Summary of the Invention

It is an object of the present invention to provide a waveguide directional filter arrangement which can be used at UHF broadcasting frequencies, and avoids the disadvantages of the aforementioned prior art.

According to a first aspect of the invention there is provided a waveguide directional filter arrangement comprising an input waveguide means and an output waveguide means connected by cavity resonator means, wherein said input waveguide means and said output waveguide means each include broad wall sections joined by narrow wall sections whose aspect ratio is greater than 2:1.

According to a second aspect of the invention there is provided a waveguide directional filter arrangement comprising an input waveguide means and an output

waveguide means, wherein each said waveguide means includes an aperture means arranged to couple its associated waveguide means to a common resonator means, and wherein edges of each aperture means include inwardly extending sections.

According to a third aspect of the invention there is provided a waveguide directional filter arrangement comprising an input waveguide means and an output waveguide means connected by cavity resonator means comprising at least three stacked resonator elements, wherein at least one pair of non-adjacent resonator elements include additional covering means to couple the non-adjacent resonator elements.

According to a fourth aspect of the invention there is provided a waveguide directional filter arrangement comprising an input waveguide means and an output waveguide means connected by a cavity resonator means comprising at least one resonator element, said input waveguide means and said output waveguide means each include broad wall sections joined by narrow wall sections whose aspect ratio is greater than 2:1, each said waveguide means includes an aperture means arranged to couple its associated waveguide means to said cavity resonator means, wherein edges of each aperture means include inwardly extending sections.

In highly selective bandpass filters which use adjacent cavity resonators coupled by apertures in common walls, the magnitudes of such couplings are very critical parameters.

In order to achieve these necessary critical parameters it is known to provide a high degree of manufacturing precision. However, this solution is unattractive for large filters.

It is therefore a further object of the present invention to provide an adjustable coupling aperture arrangement for adjusting the coupling of cavity resonators over a wide range of coupling values, the coupling being adjusted externally using a tool that does not disturb the filter's characteristics.

According to a fifth aspect of the invention, in a microwave filter comprising a housing within which is disposed at least two cavity resonators coupled by aperture means in a substantially planar wall common to both said resonators, there is provided an adjustable coupling aperture arrangement including aperture means

comprising at least one slit of predetermined dimensions, the at least one slit communicating with a respective access hole in said housing via an associated passageway that lies within the boundary of said wall's major surfaces, wherein said at least one slit is provided with a moveable metal slug that is slideably retained by opposite longitudinal edges of the slit, whereby said slug can be engaged and slideably manipulated by a tool means, introduced into said access hole and guided to said slug via said passageway, into a position in which electrical contact between said slug and said edges of the slit produces a desired change in effective electrical length of the slit.

Brief Description of the Drawings

In order that the invention may be readily carried into effect, embodiments thereof will now be described in relation to the accompanying drawings, in which:

Figure 1 shows a waveguide directional filter assembly of the present invention.

Figure 2 shows a more detailed view of the aperture arrangement of the assembly shown in Figure 1.

Figure 3 shows an alternative aperture arrangement.

Figure 4 shows a waveguide direction filter assembly with additional coupling between non-adjacent resonators.

Figure 5 is a top view of a cavity wall within a coaxial filter housing, the cavity wall being provided with an adjustable coupling iris.

Figure 6 is a top view of the cavity wall shown in Figure 5, showing radial passageways connecting slits of the coupling iris to the filter housing exterior.

Figure 7 is a side view of Figure 6.

Figure 8 is a top view of an expanded adjustment slug.

Figure 9 is a top view of a contracted adjustment slug.

Figure 10 is an end view of a adjustment slug.

Figure 11 is a side view of a cavity wall showing an adjustment slug located within a slit of the coupling iris.

Detailed Description

Referring to Figure 1, the assembly comprises an input waveguide 1 having a narrow band input port and an absorbing termination port; and an output waveguide 2 having a wideband input port and an output port. The waveguides are rectangular having broad walls 3 joined to narrow walls 4 whose aspect ratio is approximately 4:1.

Waveguides 1 and 2 are connected by six circularly cylindrical aperture coupled cavities 5. Coupling between adjacent cavities is provided by circular apertures 6.

Each end cavity is operatively coupled to its associated rectangular waveguide through a characteristically shaped aperture 7, 7a. Referring to Figure 2, aperture 7a, which is similar to aperture 7 in input waveguide 1, is in the form of a rectangle whose four sides have integral inwardly extending hemicycle sectors 8, 9, 10 and 11. These hemicycle sections provide increased coupling into the desired resonator mode.

It will be understood that the inwardly extending hemicycle sections can be in the form of discrete elements, such as for example discs, that can be attached around the edges of a basic rectangular aperture. The position of such discrete elements can be made adjustable to vary the coupling through the aperture.

Alternatively, the inwardly extending hemicycle sections can be in the form of cylinders 12, 13, 14 and 15 as shown in Figure 3. As with the above mentioned discs, the position of the cylinders can be adjustable to vary the coupling through the aperture. Moreover, the cylindrical form causes a greater reduction of coupling into undesirable modes.

Referring to Figure 4, non-adjacent resonator elements 16 and 17 of the waveguide directional filter assembly are provided with two additional coupling elements 19 and 20. Each coupling element comprises two probes 21 and 22 connected by a transmission line 23. The probes extend into the resonators and are disposed at 90^0 to one another.

The power handling capability of the waveguide directional filter arrangement described above can be enhanced by the addition of cooling fins (not shown) on one or more of the cavity resonators.

Also, tuning elements (not shown) can be added to the cavity resonators.

In operation, a narrow band signal is injected into the input port of input waveguide 1. This signal is coupled through aperture 7 into the first cavity resonator and launches a circularly polarised wave therein which is coupled through successive circularly cylindrical resonators 5 by means of circular apertures 6 to the output waveguide 2 via aperture 7a, where it produces a directional wave. This signal is added to any existing signals travelling through the same waveguide at other frequencies.

An absorbing termination coupled to waveguide 1 absorbs any power not coupled into the first resonator.

The reduced height of the waveguides improves the circularity of the circularly polarised wave in the resonators, which provides improved directional characteristics in the output waveguide across the operational band.

An advantage of the waveguide directional filter assembly of the present invention vis-a-vis the prior art assembly using separate hybrids and filters is that the assembly of the present invention is relatively unaffected by temperature differentials which can occur between separate filters in a hybrid coupled configuration. Such temperature differentials lead to a degradation of performance.

Referring to Figures 5 and 6, the adjustable coupling aperture arrangement comprises an electrically conductive wall 24 coaxially located within a filter housing 25. Wall 24 is provided with a cruciform iris 26 comprising a central zone 27 having four slits 28, 29, 30 and 31 extending outwardly therefrom. Each slit is connected by a radial passageway 32, 33, 34 and 35 to respective apertures 25a, 25b, 25c and 25d in the filter housing permitting access to the slits from the exterior of the filter housing. The passageways are within the boundary of the wall's opposite surfaces. In each slit is arranged a captive, movable, rectangular metal slug 36, 37, 38 and 39.

Referring to Figures 8 – 11, each rectangular slug comprises two sections A and B each in the form of general trapezoids whose respective non-parallel sides 40 and 41 interface. The two sections are held together by a screw 42. One section, A, is provided with a threaded hole (not shown), which cooperates with the screw's

thread when the screw is disposed in a bore hole in section B. The screw is provided with a slotted bayonet head 43 which allows the screw to be engaged by a tool (not shown) having a T-shaped end to allow the screw to be rotated as well as allowing the associated slug to be moved linearly.

A groove 44, 45 is provided in a side of each section A and B such that when a slug is assembled by screwing the sections together, opposite parallel grooves are formed for slidably engaging the edges of respective slits . Due to cooperation between sections A and B, the width between the sides provided with the grooves is maximum when the screw is tightened as shown in Fig. 8, and minimum when the screw is loosened as shown in Fig. 9. Referring to Fig. 11, the width is such that the slug is slidably retained in a slit when the screw is loosened, and fixedly grips and makes electrical contact with opposite edges of the slit when the screw is tightened, thereby affecting the electrical length of the slit.

In operation, slugs 36, 37, 38 and 39 are located in respective slits. Desired filter transmission and reflection characteristics are obtained, using a vector network analyser and manipulating the slugs with the tool inserted into respective passageways 32, 33, 34 and 35 via associated apertures 25a, 25b, 25c and 25d. While it is preferable to use four slugs to maintain symmetry in two principal planes, it will be understood that this is not an essential requirement.

Further, in filter arrangements where only a single slit is required, either one or two slugs could be used.

The claims defining the invention are as follows:

1. A waveguide directional filter arrangement comprising input waveguide means and an output waveguide means connected by cavity resonator means, wherein said input waveguide means and said output waveguide means each include broad wall sections joined by narrow wall sections whose aspect ratio is greater than 2:1.

2. A waveguide directional filter arrangement comprising an input waveguide means and an output waveguide means, wherein each said waveguide means includes an aperture means arranged to couple its associated waveguide means to a common resonator means, and wherein edges of each aperture means include inwardly extending sections.

3. A waveguide directional filter arrangement comprising an input waveguide means and an output waveguide means connected by cavity resonator means comprising at least three stacked resonator elements, wherein at least one pair of non-adjacent resonator elements include additional coupling means to couple the non-adjacent resonator elements.

4. A waveguide directional filter arrangement comprising input waveguide means and output waveguide means connected by cavity resonator means comprising at least one resonator element, said input waveguide means and said output waveguide means each include broad wall sections joined by narrow wall sections whose aspect ratio is greater than 2:1, each said waveguide means includes an aperture means arranged to couple its associated waveguide means to said cavity resonator means, wherein edges of each aperture means include inwardly extending sections.

5. A waveguide directional filter arrangement as claimed in claim 4, comprising at least 3 stacked resonator elements, at least one pair of non-adjacent resonator elements including additional coupling means to couple the non-adjacent resonator elements.

6. A waveguide directional filter arrangement as claimed in claim 5, wherein the additional coupling means comprises a first pair of coupling elements each of which

extend into a respective non-adjacent resonator element, said coupling elements being connected together by a first external transmission line means.

7. A waveguide directional filter arrangement as claimed in claim 6, including a second pair of coupling elements each of which extend into a respective non-adjacent resonator element, said coupling elements of said second pair of coupling elements being connected together by a second external transmission line means, said first pair of coupling elements and said second pair of coupling elements being disposed in a pre-determined spaced relationship.

8. A waveguide directional filter arrangement as claimed in claim 7, wherein said first pair of coupling elements and said second pair of coupling elements are disposed at approximately 90^0 to each other.

9. A waveguide directional filter arrangement as claimed in any one of claims 2, 4 to 8, wherein said inwardly extending sections are approximately hemicycle-shaped planar sections.

10. A waveguide directional filter arrangement as claimed in claim 9, wherein said hemicycle-shaped planar sections are integral with said aperture means.

11. A waveguide directional filter arrangement as claimed in claim 9, wherein said hemicycle-shaped planar sections are in the form of discrete members attached proximate said edges of said aperture means.

12. A waveguide directional filter arrangement as claimed in claims 2, 4 to 8, wherein said inwardly extending sections are hemicycle-shaped portions of cylinders, whose axes are normal to said aperture's major plane.

13. A waveguide directional filter arrangement as claimed in claim 12, wherein said cylinders are integral with said aperture means.

14. A waveguide directional filter arrangement as claimed in claim 12, wherein said cylinders are in the form of discrete members attached proximate said edges of said aperture means.

15. A waveguide directional filter arrangement as claimed in claim11, wherein said discrete members include adjustment means for positional adjustment thereof.

16. A waveguide directional filter arrangement as claimed in claim 14, wherein said discrete cylinders include adjustment means for positional adjustment thereof.

17. A waveguide directional filter arrangement as claimed in any one of claims 4-16, wherein the aspect ratio of said wall sections is approximately 4:1.

18. A waveguide directional filter arrangement as claimed in any one of claims 3 to 17, wherein at least one said resonator element includes a plurality of cooling fins operatively attached thereto.

19. A waveguide directional filter arrangement as claimed in any one of claims 3 to 18, wherein at least one said resonator element includes at least one tuning element means.

20. A waveguide directional filter arrangement as claimed in any one of the preceding claims, wherein said resonator element is symmetric.

21. A waveguide directional filter arrangement, substantially as herein described with reference to Figures 1-4 of the accompanying drawings.

22. In a microwave filter comprising a housing within which is disposed at least two cavity resonators coupled by aperture means in a substantially planar wall common to both said resonators, an adjustable coupling aperture arrangement including aperture means comprising at least one slit of predetermined dimensions, the at least one slit communicating with a respective access hole in said housing via an associated passageway that lies within the boundary of said wall's major surfaces, wherein said at least one slit is provided with a moveable metal slug that is slideably retained by opposite longitudinal edges of the slit, whereby said slug can be engaged and slideably manipulated by a tool means, introduced into said access hole and guided to said slug via said passageway, into a position in which electrical contact between said slug and said edges of the slit produces a desired change in effective electrical length of the slit.

23. An adjustable aperture arrangement as claimed in claim 22, wherein said slug includes a screw operated locking means arranged to be actuated by said tool means for locking said slug in said position.

24. An adjustable aperture arrangement as claimed in claim 23, wherein said slug is a rectangular-shaped block having a groove in each of two opposite parallel sides for cooperating with opposite edges of said slit for slideably retaining and gripping said block therein, said block being formed from a first trapezoid-shaped section

and a second trapezoid-shaped section assembled together, with each section's non-parallel side interfacing, by a screw having a head and a threaded section, said screw's threaded section freely passing through a hole in the first trapezoid section to cooperate with a threaded hole provided in the second trapezoid-shaped section, whereby the width between said grooves can be varied by a turning adjustment of said screw with said tool means engaging the screw's head to change the positional relationship between the said interfacing non-parallel sides to cause the slug to be either slideably retained within the slit for manipulation, or fixedly locked in electrical contact with said edges of said slit.

25. An adjustable aperture arrangement as claimed in claim 24, wherein said aperture means comprises four slits of predetermined dimensions, extending outwardly from a central zone, each slit including a said slug, and each slit communicating with a respective said access hole via an associated said passageway.

26. An adjustable aperture arrangement as claimed in claim 25, wherein said planar wall is substantially circular in shape.

27. An adjustable aperture arrangement as claimed in any one of claims 24, 25 or 26, wherein the screw head includes a bayonet socket for cooperating with a tool having a T-shaped end.

28. An adjustable aperture arrangement substantially as herein described with reference to Figs. 5 – 11 of the accompanying drawings.

29. An adjustable aperture arrangement as claimed in any one of claims 22 to 28, operatively incorporated in a waveguide directional filter arrangement as claimed in any one of claims 1 to 21.

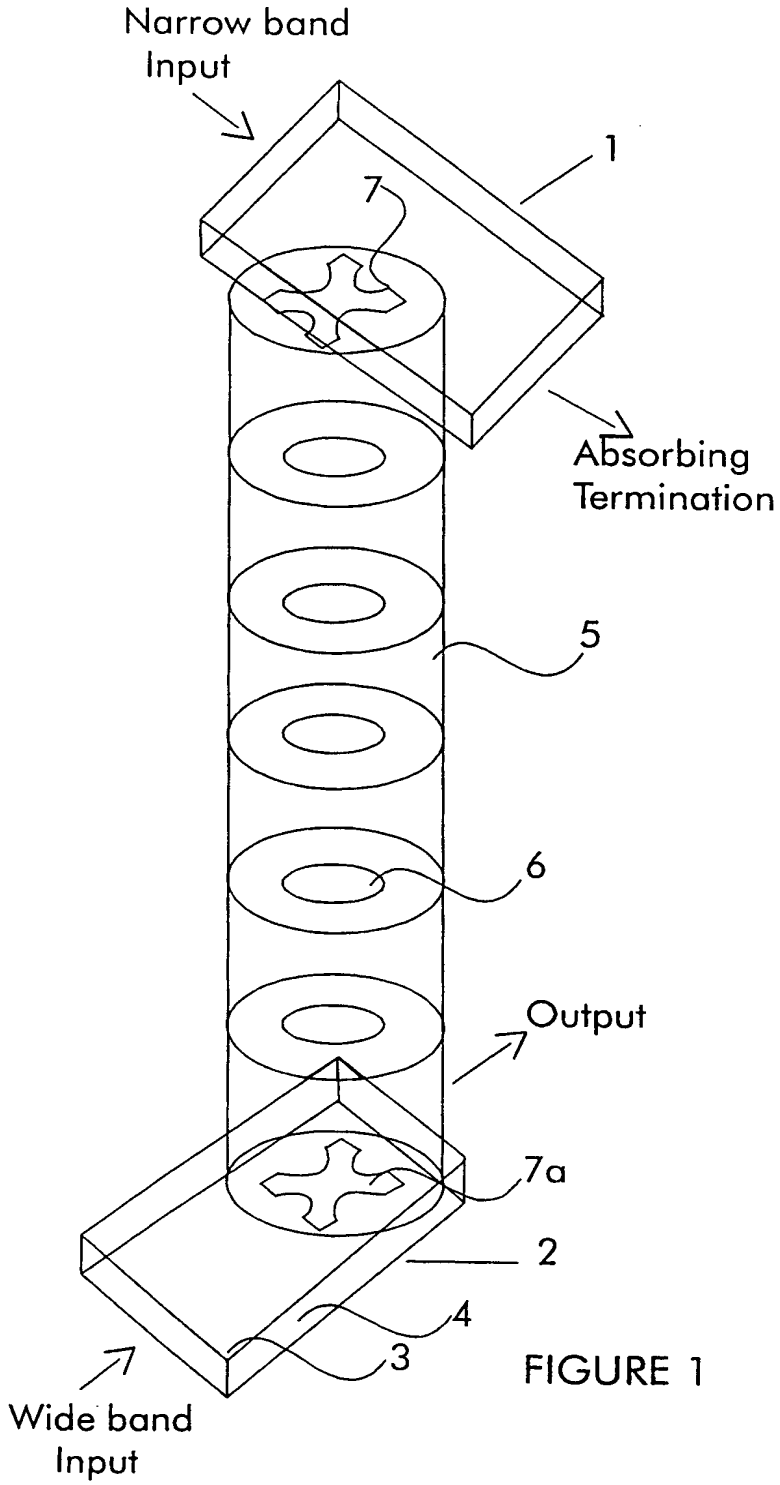
Narrow band
Input
1
7
Absorbing
Termination
5
6
Output
7a
2
4
3
Wide band
Input

FIGURE 1

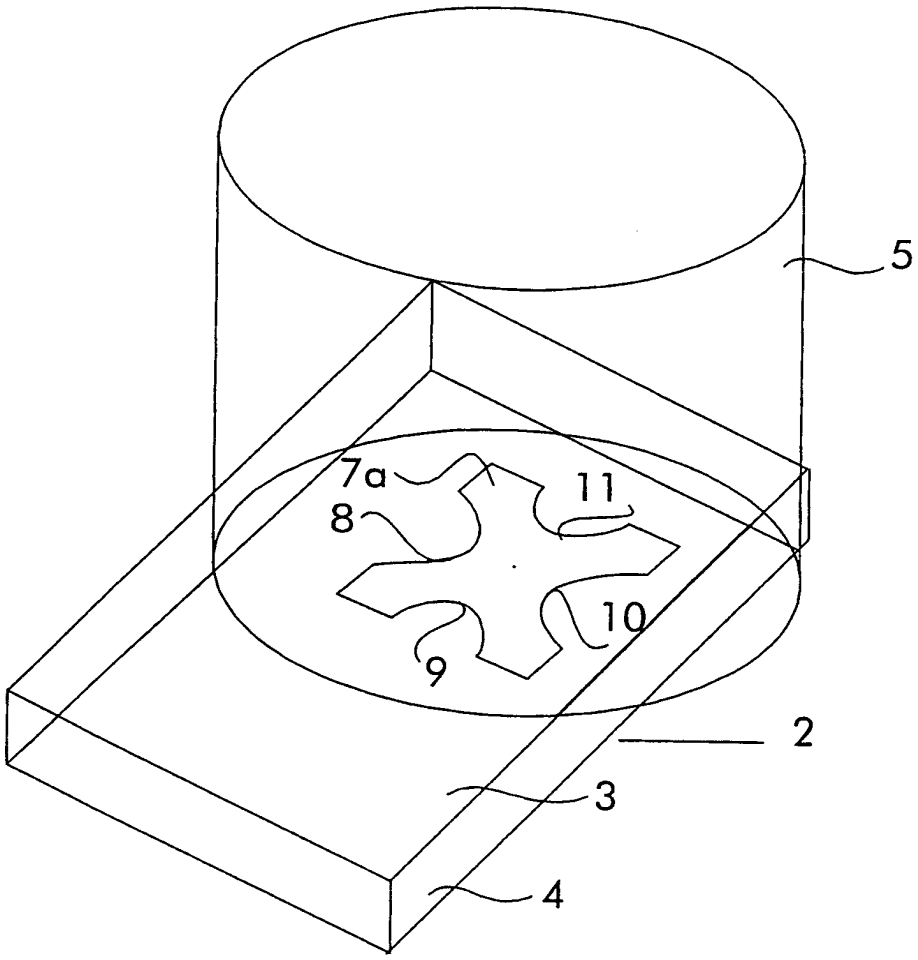

FIGURE 2

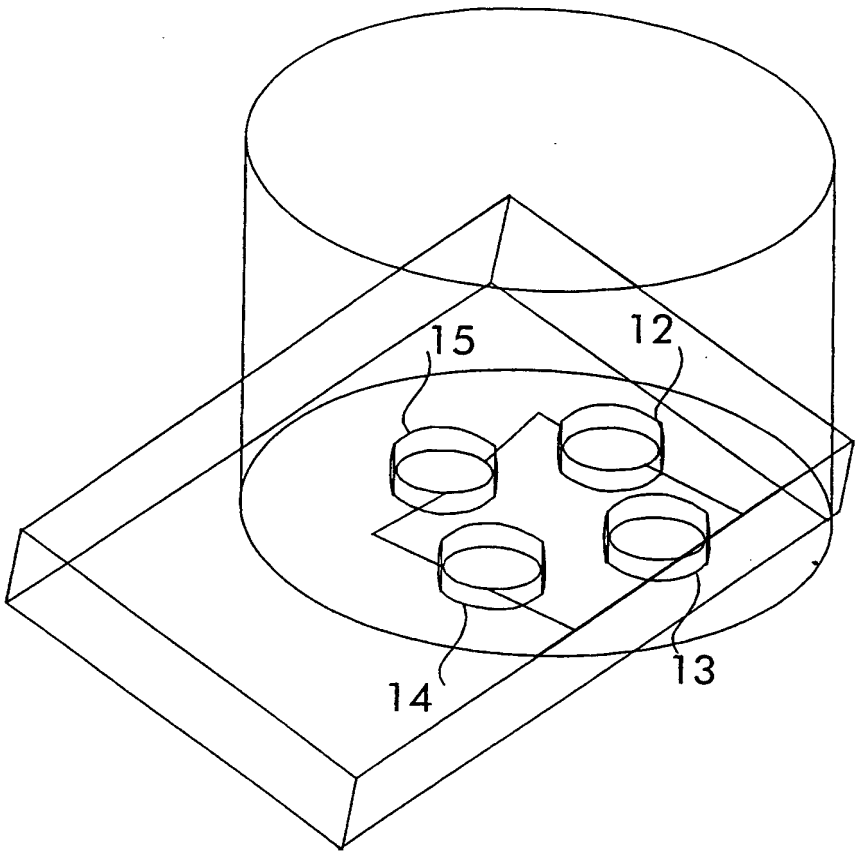

FIGURE 3

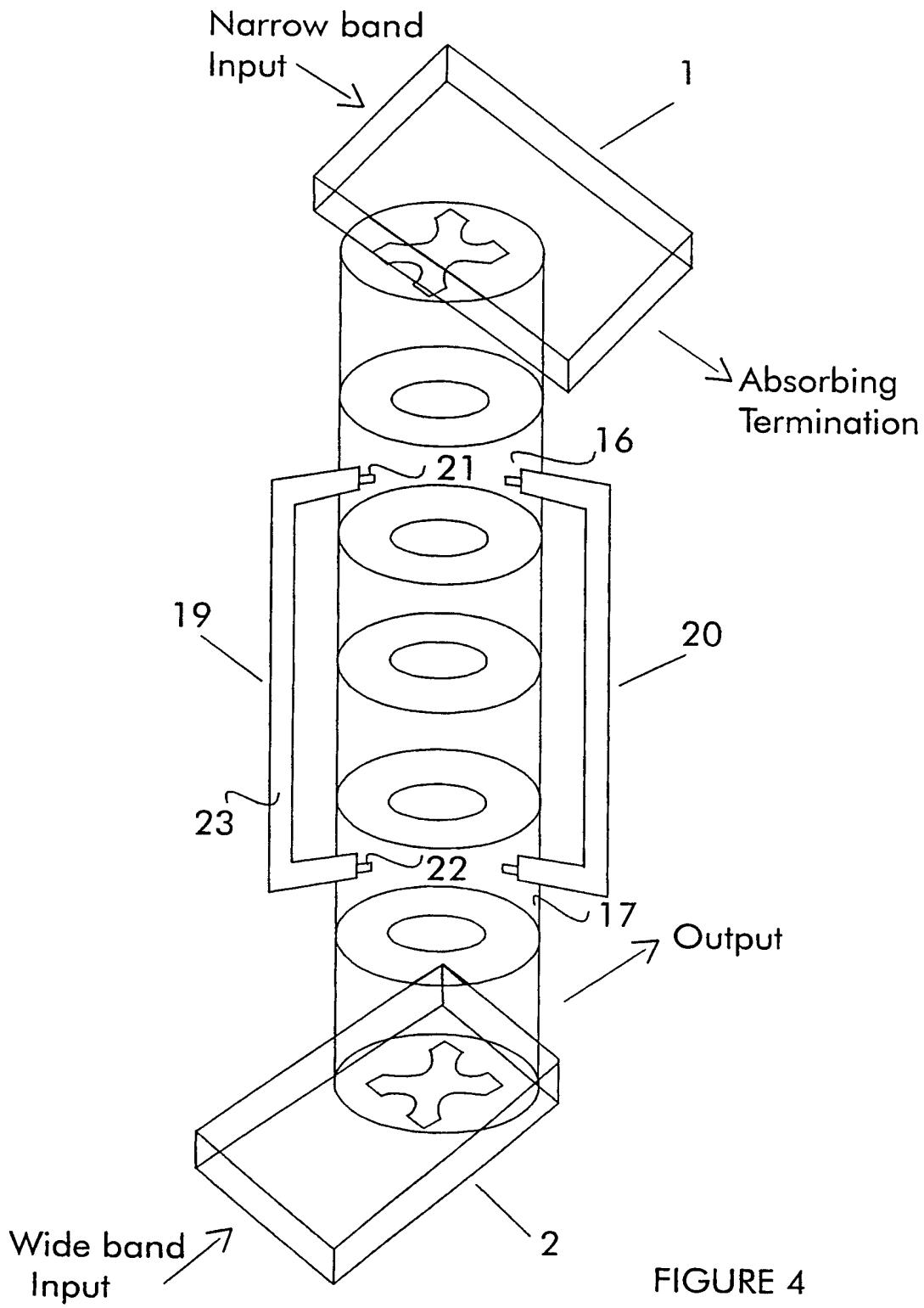
Narrow band
Input
1
Absorbing
Termination
16
21
19
20
23
22
17
Output
Wide band
Input
2

FIGURE 4

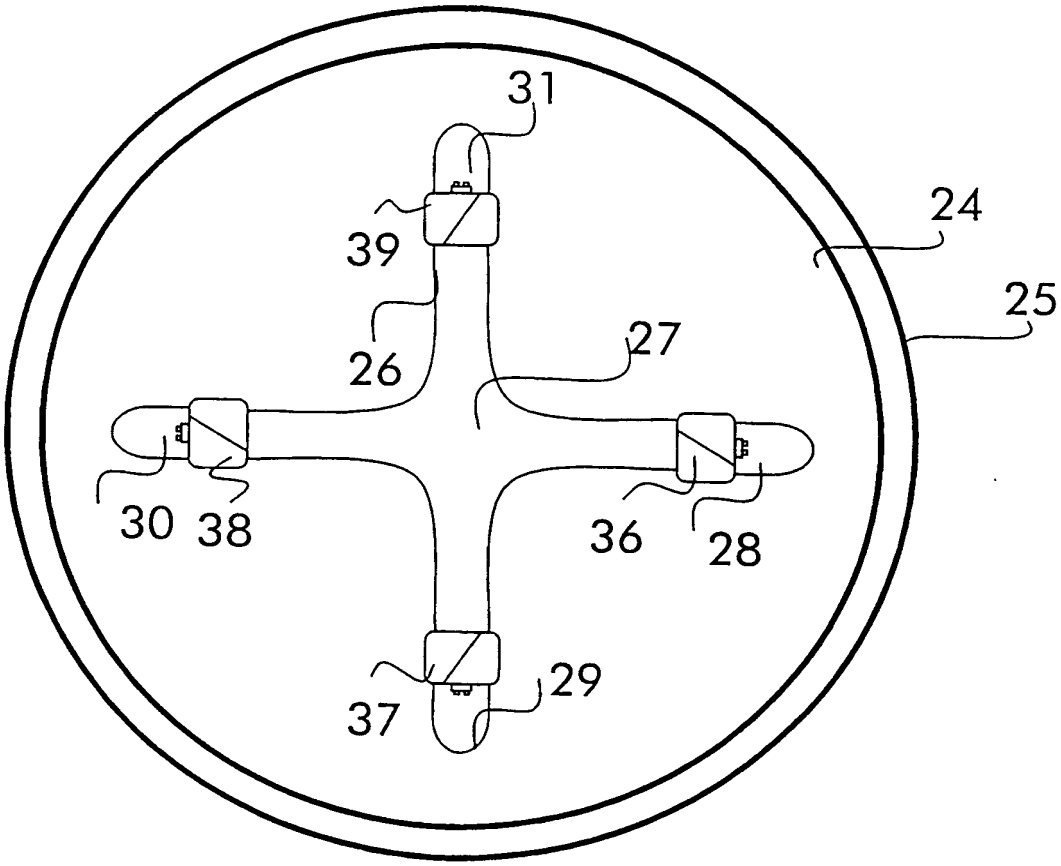

FIGURE 5

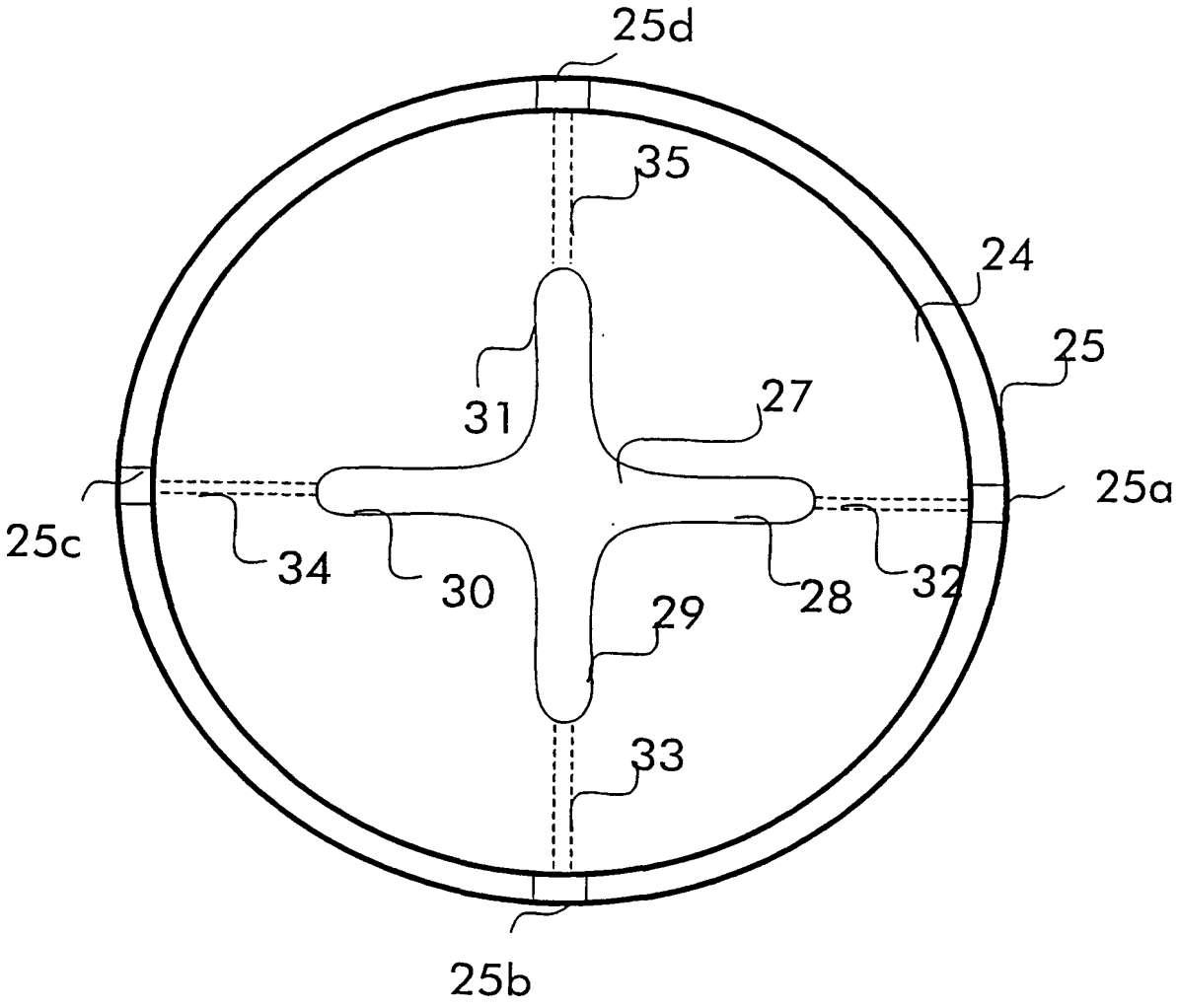

FIGURE 6

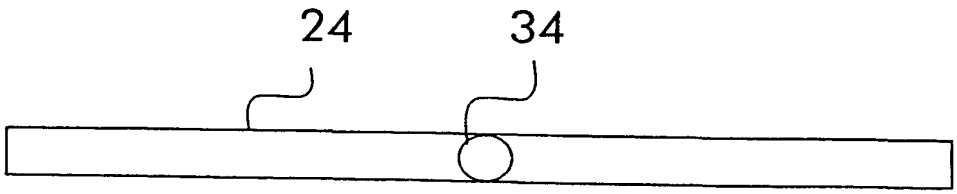

FIGURE 7

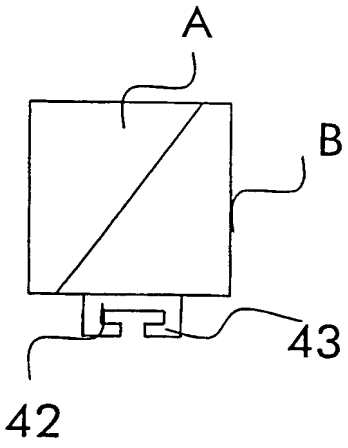

FIGURE 8

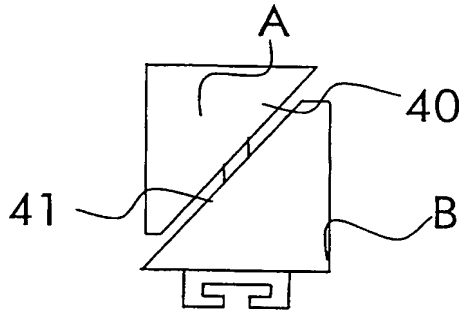

FIGURE 9

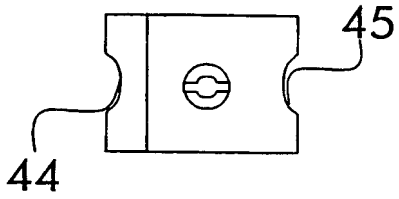

FIGURE 10

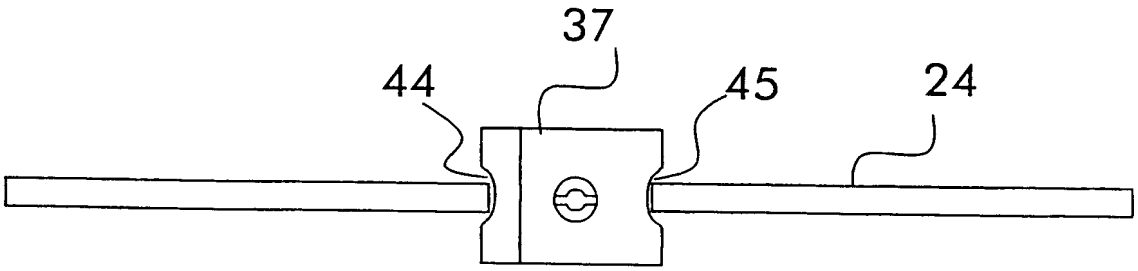

FIGURE 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU 99/01071

A. CLASSIFICATION OF SUBJECT MATTER

Int Cl[7]: H01P 1/208, H01P 1/213

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC: H01P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPAT, JAPIO

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	Patent Abstracts of Japan, JP 63-155803 (Mitsubishi Electric Corp) 29 June 1988	1,2,4 21,22,23
X	Patent Abstracts of Japan, JP 61-065501 (NEC Corp.) 4 April 1986	1,3
X	Patent Abstracts of Japan, JP 58-205301 (NTT Corp, Mitsubishi Corp.) 30 November 1983	1,2

[X] Further documents are listed in the continuation of Box C

[ ] See patent family annex

* Special categories of cited documents:

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"O" Document referring to an oral disclosure, use, exhibition or other means

"P" Document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 January 2000	31 January 2000 (31.01.00)
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer **ANDREA HADLEY** Telephone No.: (02) 6283 2222

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU 99/01071

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Patent Abstracts of Japan, JP 58-013001 (NEC Corp.) 25 January 1983	1
X	DE 4116755 (ANT Nachrichtentechnik GmbH) 26 November 1992 (see Figures 1 and 2)	1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU 99/01071

Box 1 Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Independent claim 1 defines a directional filter with input and output waveguides connected by a cavity resonator, the waveguides including broad and narrow wall sections whose aspect ratio is greater than 2:1. Independent claim 2 defines a directional filter with input and output waveguides coupled to a common resonator via apertures with inwardly extending sections. Independent claim 3 defines a directional filter with input and output waveguides coupled by a cavity resonator with at least three stacked resonator elements.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims

2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark n Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.